Average balance equations, scale dependence and energy cascade for granular materials

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ABSTRACT

A new averaging method linking discrete to continuum variables of granular materials is developed and used to derive average balance equations [1]. Its novelty lies in the choice for the decomposition between mean values and fluctuations of properties which takes into account the effect of gradients. Thanks to a local homogeneity hypothesis, whose validity is discussed, simplified balance equations are obtained.

This original approach solves the problem of dependence of some variables on the size of the averaging domain obtained in previous approaches [2] which can lead to important relative errors (several hundred percent). It also clearly separates affine and non-affine fields in the balance equations.

The resulting energy cascade picture is discussed, with a particular focus on unidirectional steady and fully developed flows for which it appears that the contact terms are dissipated locally unlike the kinetic terms which contribute to a nonlocal balance.

Application of the method is demonstrated in the determination of the macroscopic properties such as volume fraction, velocity, stress, and energy of a simple shear flow, where the discrete results are generated by means of discrete particle simulation.

REFERENCES

[1] R. Artoni and P. Richard, submitted (2014).
[2] M. Babic, International Journal of Engineering Science 35, 523 (1997).